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[Name of Document] Abstract 1

[General Power of Attorney's Number] 0108331

[Proof] Required

[Document Name] SPECIFICATION

[Title of the Invention] ULTRASONIC DIAGNOSTIC APPARATUS

[Claims]

[Claim 1] An ultrasonic diagnostic apparatus, comprising:

a transmission unit that transmits at least one ultrasonic signal from a surface of a subject toward a blood vessel within the subject;

a reception unit that receives an ultrasonic echo signal reflected by the blood vessel and converts the same into an electric signal;

a movement detection unit that analyzes a phase of an ultrasonic echo signal in a direction intersecting a center axis of the blood vessel so as to calculate a movement amount of the blood vessel wall of the blood vessel;

a conversion unit that converts a phase change of the ultrasonic echo signal into a hardness value of tissues along the depth direction from the surface of the skin; and

a boundary position detection unit that detects a boundary position between an inner membrane of the blood vessel and a blood flow region where blood flows through the blood vessel and a position of the middle membrane based on a hardness value of tissues along the depth direction.

[Claim 2] The ultrasonic diagnostic apparatus according to claim 1, further comprising a region of interest placement unit that places the region of interest for obtaining the hardness value of tissues along the depth direction from the surface of the skin so as to lie over at least one of an anterior wall of the blood vessel wall on a side closer to the transmission unit and a posterior wall of the blood vessel wall on a side farther from the transmission unit.

[Claim 3] The ultrasonic diagnostic apparatus according to claim 1 or 2, further comprising a calculation unit that measures a thickness from

the inner membrane to the middle membrane based on a variation over time in the boundary position between the inner membrane of the blood vessel and the blood flow region, and a variation over time in the position of the middle membrane.

[Claim 4] The ultrasonic diagnostic apparatus according to any one of claims 1 to 3, wherein the calculation unit measures the thickness from the inner membrane to the middle membrane based on a variation over time in the boundary position and a variation over time in the position of the middle membrane in one heartbeat cycle.

[Claim 5] The ultrasonic diagnostic apparatus according to claim 3, wherein the calculation unit calculates at least one of a maximum value, a minimum value and an average value of the thickness in one heartbeat cycle.

[Claim 6] The ultrasonic diagnostic apparatus according to any one of claims 1 to 5, wherein the transmission unit transmits a plurality of ultrasonic pulses toward a plurality of points along a longitudinal direction of the blood vessel, and the calculation unit measures the thickness at each of the plurality of points.

[Claim 7] The ultrasonic diagnostic apparatus according to any one of claims 1 to 6, further comprising a display unit that displays a point at which a maximum thickness is measured among the thicknesses measured at the plurality of points.

[Claim 8] The ultrasonic diagnostic apparatus according to any one of claims 1 to 7, wherein the blood vessel extends in a direction tilted with respect to the surface of the skin, and the ultrasonic diagnostic apparatus further comprising an angle correction unit that performs angle correction with respect to the thickness calculated by the calculation unit based on a

difference in depth of the plurality of points from the surface of the skin.

[Claim 9] The ultrasonic diagnostic apparatus according to any one of claims 1 to 8, further comprising a stability determination unit that determines the stability of the thickness calculated by the calculation unit by comparing the thickness calculated by the calculation unit with a thickness obtained a predetermined number or more of cycles before.

[Claim 10] The ultrasonic diagnostic apparatus according to any one of claims 1 to 9, wherein the transmission unit transmits a plurality of the ultrasonic pulses toward a plurality of points along a longitudinal direction of the blood vessel, the calculation unit measures the thickness at each of the plurality of points, and the ultrasonic diagnostic apparatus further includes a stability determination unit that determines stability of the thickness calculated by the calculation unit by comparing the thicknesses measured at the plurality of points one another.

[Claim 11] The ultrasonic diagnostic apparatus according to any one of claims 3 to 10, further comprising a unit that displays a value of the thickness calculated by the calculation unit on a monitor.

[Claim 12] The ultrasonic diagnostic apparatus according to any one of claims 1 to 11, further comprising a unit that displays on a monitor a hardness value of tissues converted by the conversion unit.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to an ultrasonic diagnostic apparatus that has a function of diagnosing a state of blood vessels using ultrasonic waves.

[0002]

[Prior Art]

As a method of detecting an IMT (Intima-Media Thickness: a thickness from an inner membrane to a middle membrane) value of a blood vessel wall (carotid artery) using ultrasonic waves, a method is known that measures an IMT value of the blood vessel wall (carotid artery) based on a maximum peak value and a second peak value of a brightness signal in a image data obtained based on ultrasonic waves reflected by the blood vessel, assuming that a blood vessel has a normal structure (for example, see PATENT DOCUMENT 1).

[0003]

[PATENT DOCUMENT 1]

Japanese Patent No. 2889568

[0004]

[Problems to be Solved by the Invention]

In the above-described conventional technologies, however, since the brightness signal of image data is utilized for analyzing a structure of the blood vessel wall as a target of the measurement for an IMT value of the blood vessel wall, if a brightness of an inner membrane of the blood vessel wall as the target of the measurement is low, there is a problem that the IMT value of the blood vessel wall cannot be measured correctly.

[0005]

It is an object of the present invention to provide an ultrasonic diagnostic apparatus that is capable of measuring an IMT value of a blood vessel wall correctly using ultrasonic waves.

[0006]

[Means for Solving the Problems]

An ultrasonic diagnostic apparatus according to the present

invention includes: a transmission unit that transmits at least one ultrasonic signal from a surface of a subject toward a blood vessel within the subject; a reception unit that receives an ultrasonic echo signal reflected by the blood vessel and converts the same into an electric signal; a movement detection unit that analyzes a phase of an ultrasonic echo signal in a direction intersecting a center axis of the blood vessel so as to calculate a movement amount of the blood vessel wall of the blood vessel; and a conversion unit that converts a phase change of the ultrasonic echo signal into a hardness value of tissues along the depth direction from the surface of the skin; and a boundary position detection unit that detects a boundary position between an inner membrane of the blood vessel and a blood flow region where blood flows through the blood vessel and a position of the middle membrane based on a hardness value of tissues along the depth direction.

[0007]

With this configuration, the boundary position between the blood vessel wall and the blood flow region can be detected correctly without the influence of a variation in brightness value of an inner membrane existing in the subject even in the case where there is a local lesion such as an atheroma in the blood vessel.

[0008]

Preferably, an ultrasonic diagnostic apparatus according to the present invention further includes a region of interest placement unit that places the region of interest for obtaining the hardness value of tissues along the depth direction from the surface of the skin so as to lie over at least one of an anterior wall of the blood vessel wall on a side closer to the transmission unit and a posterior wall of the blood vessel wall on a side

farther from the transmission unit. With this configuration, the boundary position between the inner membrane of the blood vessel and the blood flow region where blood flows through the blood vessel and the position of the middle membrane can be detected.

[0009]

Preferably, an ultrasonic diagnostic apparatus according to the present invention further includes a calculation unit that measures a thickness from the inner membrane to the middle membrane based on a variation over time in the boundary position between the inner membrane of the blood vessel and the blood flow region, and a variation over time in the position of the middle membrane. With this configuration, the boundary position between the inner membrane of the blood vessel and the blood flow region and the position of the middle membrane can be detected.

[0010]

Preferably, an ultrasonic diagnostic apparatus according to the present invention includes that the calculation unit measures the thickness from the inner membrane to the middle membrane based on a variation over time in the boundary position and a variation over time in the position of the middle membrane in one heartbeat cycle. With this configuration, the thickness from the inner membrane to the middle membrane can be measured accurately.

[0011]

Preferably, an ultrasonic diagnostic apparatus according to the present invention includes that the calculation unit calculates at least one of a maximum value, a minimum value and an average value of the thickness in one heartbeat cycle. With this configuration, the thickness from the inner membrane to the middle membrane can be measured by a simple

method.

[0012]

Preferably, an ultrasonic diagnostic apparatus according to the present invention includes that the transmission unit transmits a plurality of ultrasonic pulses toward a plurality of points along a longitudinal direction of the blood vessel, and the calculation unit measures the thickness at each of the plurality of points. With this configuration, a thickness distribution can be obtained along the longitudinal direction of the blood vessel.

[0013]

Preferably, an ultrasonic diagnostic apparatus according to the present invention further includes a display unit that displays a point at which a maximum thickness is measured among the thicknesses measured at the plurality of points. With this configuration, a thickness distribution along the longitudinal direction of the blood vessel easily can be recognized visually.

[0014]

Preferably, an ultrasonic diagnostic apparatus according to the present invention includes that the blood vessel extends in a direction tilted with respect to the surface of the skin, and the ultrasonic diagnostic apparatus further includes an angle correction unit that performs angle correction with respect to the thickness calculated by the calculation unit based on a difference in depth of a plurality of points from the surface of the skin. With this configuration, a thickness of a blood vessel extending in a direction tilted with respect to the surface of the skin can be measured accurately.

[0015]

Preferably, an ultrasonic diagnostic apparatus according to the present invention further includes a stability determination unit that determines the stability of the thickness calculated by the calculation unit by comparing the thickness calculated by the calculation unit with a thickness obtained a predetermined number or more of cycles before. With this configuration, a measurer may be notified of the thus determined stability, whereby the measuring time can be shortened.

[0016]

Preferably, an ultrasonic diagnostic apparatus according to the present invention includes that the transmission unit transmits a plurality of the ultrasonic pulses toward a plurality of points along a longitudinal direction of the blood vessel, the calculation unit measures the thickness at each of the plurality of points, and the ultrasonic diagnostic apparatus further includes a stability determination unit that determines stability of the thickness calculated by the calculation unit by comparing the thicknesses measured at the plurality of points one another. With this configuration, a measurer may be notified of the thus determined stability, whereby the measuring time can be shortened.

[0017]

Preferably, an ultrasonic diagnostic apparatus according to the present invention further includes a unit that displays a value of the thickness calculated by the calculation unit on a monitor. With this configuration, the calculated thickness value can be visually recognized.

[0018]

Preferably, an ultrasonic diagnostic apparatus according to the present invention further includes a unit that displays on a monitor a hardness value of tissues converted by the conversion unit. With this

configuration, the hardness value of tissues can be recognized visually.

[0019]

[Modes for Carrying Out the Invention]

The following describes embodiments of the present invention, with reference to the drawings.

[0020]

(Embodiment 1)

Fig. 1 is a block diagram schematically showing a configuration of an ultrasonic diagnostic apparatus 100 according to Embodiment 1 of the present invention. The ultrasonic diagnostic apparatus 100 includes a transmission unit 4. The transmission unit 4 generates an ultrasonic pulse and supplies it to an ultrasonic probe 101. The ultrasonic probe 101 transmits the ultrasonic pulse supplied from the transmission unit 4 from the surface of the skin of a living body toward the blood vessel 10 within the living body.

[0021]

The blood vessel 10 extends in a direction tilted with respect to the surface of the skin and has a blood vessel wall 103 that is configured to define a blood flow region 104 through which blood flows. The blood vessel walls 103 includes an inner membrane 13 that is formed on an inside of the blood vessel wall 103 so as to define the blood flow region 104, an outer membrane 11 formed on an outside of the blood vessel wall 103, and a middle membrane 12 formed between the inner membrane 13 and the outer membrane 11. An atheroma 106 as a local lesion develops between the inner membrane 13 and the middle membrane 12. The blood vessel wall 103 includes an anterior wall on a side closer to the ultrasonic probe 101, and a posterior wall on a side farther from the ultrasonic probe 101.

[0022]

An ultrasonic pulse reflected by the blood vessel 10 is received by an ultrasonic probe 101, and is imparted to a movement detection unit 3 via a reception unit 110 and a delay synthesis unit 111.

[0023]

The movement detection unit 3 detects and analyzes a phase of the ultrasonic echo signal along a depth direction from the surface of the skin based on the ultrasonic echo received by the ultrasonic probe 101 so as to calculate a movement amount of the blood vessel wall.

[0024]

The ultrasonic diagnostic apparatus 100 includes a hardness value conversion unit 2. The hardness value conversion unit 2 converts a phase change of the ultrasonic echo signal detected by the movement detection unit 3 into a hardness value of tissues along the depth direction from the surface of the skin.

[0025]

The ultrasonic diagnostic apparatus 100 includes a boundary position detection unit 1. The boundary position detection unit 1 detects a boundary position between the inner membrane 13 of the blood vessel 10 and the blood flow region 104 where blood flows through the blood vessel 10 based on the hardness value of tissues along the depth direction and a position of the middle membrane 12. The boundary position detection unit 1 further generates a two-dimensionally mapped color display image showing a cross section of the blood vessel 10, and supplies it to an image synthesis unit 116.

[0026]

The ultrasonic diagnostic apparatus 100 includes a B-mode

processing unit 113. The B-mode processing unit 113 generates image information representing a cross section of the blood vessel 10 based on the ultrasonic pulse supplied via a delay synthesis unit 111, and supplies it to the image synthesis unit 116.

[0027]

The image synthesis unit 116 synthesizes the image information supplied from the B-mode processing unit 113 and the image information supplied from the boundary position detection unit 1, and displays the resultant on a monitor of a display unit 8.

[0028]

Fig. 2 is a schematic view for explaining an operation of the ultrasonic diagnostic apparatus 100 according to Embodiment 1. This Fig.2 shows a case where a boundary position is detected by utilizing a hardness value of tissues converted by the hardness value conversion unit 2 based on the ultrasonic pulse reflected by the blood vessel 10. In addition, Fig. 2 shows a case where a boundary position between the inner membrane 13 and the blood flow region 104 is detected by utilizing echo brightness detected by the conventional echo brightness detection unit for the convenience of explanation.

[0029]

Conventionally, in order to enable the measurement of an IMT value by utilizing the echo brightness, assuming that a blood vessel as a target of the measurement has a normal blood vessel wall structure, a maximum peak value and a second peak value of a signal of brightness in image data should have been determined.

[0030]

Attention is given to point R1, point R2 and point R3 on a scanning

line 120 that shows the course of an ultrasonic pulse. Point R1 is placed at a boundary position between the inner membrane 13 and the blood flow region 104, point R2 is placed in the atheroma 106 on the blood vessel wall 103, point R3 is placed at a position on the inner membrane 12.

[0031]

As shown by the diagram of Fig. 2 (c) that shows a relationship between the echo brightness that is detected by the conventional echo brightness detection unit and the depth from the surface of the skin, the echo brightness can be detected slightly at point G1 corresponding to the boundary position between the blood vessel wall 103 and the blood flow region 104. However, since a difference from the echo brightness at point G2 corresponding to the inside of the atheroma 106 is small, there is a strong possibility that error occurs in the direction toward point G3 corresponding to a position on the inner membrane 12.

[0032]

Therefore, when the measurement of a blood vessel with the atheroma is attempted, which requires detailed diagnosis, there is a strong possibility that depending on the compositions of contents making up the atheroma, unevenness of the echo brightness may occur. Thus, it is difficult to detect the maximum peak value and the second peak value accurately.

[0033]

The use of hardness values of tissues converted by the hardness value conversion unit 2 as in Embodiment 1 allows point E1, corresponding to point R1 placed at the boundary position between the blood vessel wall 103 and the blood flow region 104, to show a much higher peak value than those of point E2 corresponding to point R2 placed in the atheroma 106,

which is free from the influence of the echo brightness. Thus, a maximum peak value at point E1 corresponding to the boundary position between the blood vessel wall 103 and the blood flow region 104 and a second peak value at point E3 corresponding to point R3 that indicates a position on the middle membrane 12 can be detected accurately and securely.

[0034]

As stated above, according to Embodiment 1, the boundary position detection unit 1 detects, based on the hardness values of tissues along the depth direction from the surface of the skin, the boundary position between the inner membrane 13 of the blood vessel 10 and the blood flow region 104 where the blood flows through the blood vessel 10 and the position of the middle membrane 12 formed between the inner membrane 13 and the outer membrane 11. Therefore, the boundary position between the blood vessel wall 103 and the blood flow region 104 can be detected correctly without the influence of a variation in brightness value of an inner membrane existing in the subject even in the case where there is a local lesion such as an atheroma 106 in the blood vessel.

[0035]

Fig. 3 is a diagram for explaining an operation of an ultrasonic diagnostic apparatus according to the present embodiment. Fig. 3 shows the state of IMT values varying during one heartbeat cycle. For instance, when a track 310 showing the movement amount of the inner membrane 13 is compared with a track 320 showing the movement amount of the middle membrane 12, each of the tracks being in synchronization with one heartbeat cycle of the ECG waveform 300, the track 320 showing the movement amount of the middle membrane 12 is smaller than the track 310 showing the movement amount of the inner membrane 13.

[0036]

This is because, as the hardness values of tissues from the inner membrane 13 to the middle membrane 12 within the range of the IMT value are small, which means that the tissues are soft, the IMT value decreases as the pressure increases as shown by a track 330, which is obtained by subtracting the movement amount of the middle membrane 12 shown by the track 320 from the movement amount of the inner membrane 13 shown by the track 310, in accordance with a variation in pressure in the blood vessel due to heartbeat.

[0037]

Therefore, for instance, by observing a maximum peak position and a second peak position at a reference time of heartbeat such as at R wave, a variation amount of the IMT value during one heartbeat cycle and a maximum value, a minimum value and an average value of the IMT value also can be confirmed.

[0038]

(Embodiment 2)

Fig. 4 is a block diagram showing a configuration of an ultrasonic diagnostic apparatus 100A according to Embodiment 2. The same reference numerals are assigned to the same elements as those of the ultrasonic diagnostic apparatus 100 described above by referring to Fig. 1. Accordingly, the detailed explanations for these elements are omitted.

[0039]

This ultrasonic diagnostic apparatus 100A is provided with a region of interest placement unit 6. The region of interest placement unit 6 places a region of interest (ROI) 107, which is for obtaining hardness values of tissues along the depth direction from the surface of the skin, so that the

region of interest lies over at least one of an anterior wall and a posterior wall. In an example of Fig. 4, the region of interest 107 is placed so as to lie over the posterior wall.

[0040]

An operation of the thus configured ultrasonic diagnostic apparatus 100A will be described below. When the region of interest placement unit 6 places the region of interest 107 so as to lie over at lease one of the anterior wall and the posterior wall, an ultrasonic pulse is transmitted toward tissues included in the region of interest 107, and a boundary position between an inner membrane 13 of a blood vessel 10 and a blood flow region 104 and a position of a middle membrane 12 are detected in a similar manner to the above-described Embodiment 1.

[0041]

(Embodiment 3)

Fig. 5 is a block diagram showing a configuration of an ultrasonic diagnostic apparatus 100B according to Embodiment 3. The same reference numerals are assigned to the same elements as those of the ultrasonic diagnostic apparatus 100A described above by referring to Fig. 4. Accordingly, the detailed explanations for these elements are omitted.

[0042]

This ultrasonic diagnostic apparatus 100B is provided with an IMT calculation unit 24. The IMT calculation unit 24 measures as an IMT (Intima-Media Thickness) value, a thickness from an inner membrane 13 to a middle membrane 12 based on a variation over time at the boundary position between the inner membrane 13 of the blood vessel 10 and the blood flow region 104 and a variation over time at the position of the middle membrane12 in one heartbeat cycle. The IMT calculation unit 24

calculates at least one of a maximum value, a minimum value, and an average value of the IMT value in one heartbeat cycle.

[0043]

Thus, a distance between point E1 indicating the maximum peak value and point E3 indicating the second peak value shown in the above-mentioned Fig. 2(b) can be detected as the IMT value.

[0044]

Fig. 6 is a schematic view for explaining another operation of the ultrasonic diagnostic apparatus 100B according to Embodiment 3. As shown in Fig. 6, the ultrasonic diagnostic apparatus can be configured so that a plurality of ultrasonic pulses shown by a plurality of scanning lines 120 are applied along the longitudinal direction of the blood vessel 10, and a boundary position detection unit 1 detects a plurality of IMT values existing in the region of interest 107 concurrently along the longitudinal direction of the blood vessel 10. In general, the maximum IMT value often serves as a representative value for the diagnosis, so that the position where the maximum IMT value is measured can be displayed on a monitor of a display unit 8.

[0045]

(Embodiment 4)

Fig. 7 is a block diagram showing a configuration of an ultrasonic diagnostic apparatus 100C according to Embodiment 4. The same reference numerals are assigned to the same elements as those of the ultrasonic diagnostic apparatus 100B described above by referring to Fig. 5. Accordingly, the detailed explanations for these elements are omitted.

[0046]

This ultrasonic diagnostic apparatus 100C is provided with an angle

correction unit 25. The angle correction unit 25 performs angle correction with respect to the IMT value calculated by the IMT value calculation unit 24 based on a difference in depth from the surface of the skin among a plurality of points.

[0047]

Fig. 8 is a schematic view for explaining an operation of the ultrasonic diagnostic apparatus 100C according to Embodiment 4. The same reference numerals are assigned to the same elements as the elements described above by referring to Figs. 1 and 2. Accordingly, the detailed explanations for these elements are omitted.

[0048]

An ultrasonic probe 101 applies ultrasonic waves along three scanning lines 120A, 120B and 120C that are spaced along the longitudinal direction of the blood vessel 10. A horizontal distance between the scanning line 120A and the scanning line 120C is a distance dL. A difference between an intersection point Ba of the scanning line 120A and a middle membrane 12 and an intersection point Bc of the scanning line 120C and the middle membrane 12 along the depth direction is denoted with a difference dD.

[0049]

An IMT(b) value at an intersection point Bb of the scanning line 120B to the middle membrane 12 is represented by an IMT(b) value 502, and an IMT(a) value after the angle correction is represented by an IMT(a) value 503.

[0050]

Using positional information of the middle membrane 12 of the blood vessel wall 103 that is obtained based on the plurality of scanning lines

120A, 120B and 120C, angle correction can be performed with respect to an IMT value. Angle correction can be performed with respect to an IMT(b) value 502 at the intersection point Bb using the following expression (1).

[0051]

$$IMT(a) = IMT(b) \times \sin[\mathrm{atan}(dL/dD)] \quad \cdots (1)$$

Naturally, the accuracy of the angle correction can be enhanced further based on positional information of points Ta, Tb and Tc where a middle membrane 12 on the side closer to the surface of the skin is located.

[0052]

Alternatively, angle correction may be performed by determining a gradient using the midpoint of the point Ta and the intersection point Ba and the midpoint of the point Tc and the intersection point Bc.

[0053]

(Embodiment 5)

Fig. 9 is a block diagram showing a configuration of an ultrasonic diagnostic apparatus 100D according to Embodiment 5. The same reference numerals are assigned to the same elements as those of the ultrasonic diagnostic apparatus 100C described above by referring to Fig. 7. Accordingly, the detailed explanations for these elements are omitted.

[0054]

This ultrasonic diagnostic apparatus 100D is provided with a stability determination unit 21. The stability determination unit 21 determines the stability of an IMT value calculated by the IMT value calculation unit 24 by comparing the IMT value calculated by the IMT value calculation unit 24 with an IMT value obtained a predetermined number or more of cycles before.

[0055]

Fig. 10 is a diagram for explaining an operation of the ultrasonic diagnostic apparatus 100D according to Embodiment 5. When ideal measurement data can be obtained in a constant state of the positional relationship between the subject and the ultrasonic probe 101 or in a stable state of the subject by stopping his/her breathing, the blood vessel wall has similar movement tracks in heartbeats. The stability of the measurement of detecting an IMT value is determined by utilizing this.

[0056]

For instance, a region range including an allowable error range 611 added to a movement track 610 in the immediately preceding cycle in synchronization with the heartbeat cycle of the ECG waveform 600 is compared with a movement track in a subsequent measurement cycle. In the case where the entire movement track falls within the region range including the allowable error range 611 added to, as in the movement track 620 when the data is stably determined, the measurement is determined to be stable. In the case where the entire movement track that deviates from the region range including the allowable error range 611 added to is present, as in the movement track 630 when the data is not stably determined, the measurement is determined to be unstable.

[0057]

When a measurer is notified of such information indicating stable measurement or unstable measurement in real time, it becomes possible for the measurer to determine during the measurement as to whether the current measurement result is reliable or not. As a result, the measuring time can be shortened.

[0058]

Certainly, the determination concerning stable measurement or

unstable measurement may be made based on a difference between the measurement result in the present cycle and that in the immediately preceding cycle. Further, the determination concerning stable measurement or unstable measurement may be made based on the comparison with not only the immediately preceding cycle but also stably measured movement tracks in a plurality of past cycles.

[0059]

Further, the threshold value (allowable error range 611) for the determination concerning stable measurement or unstable measurement may be changed. Moreover, regarding values determined from an echo brightness value that is unsuitable for boundary determination, such as a value of pseudo boundary determination position, a value obtained in the immediately preceding cycle and a value obtained in the present cycle may be compared with each other. Consequently, by combining these plural functions of determining measuring stability, the reliability of a measurement result can be enhanced further.

[0060]

[Effects of the Invention]

According to the present invention as described above, an ultrasonic diagnostic apparatus capable of measuring an IMT value of a blood vessel wall correctly using ultrasonic waves can be provided.

[Brief Description of the Drawings]

[FIG. 1] A block diagram for explaining a configuration of an ultrasonic diagnostic apparatus according to Embodiment 1.

[FIG 2] (a) or (c) is a schematic view for explaining an operation of the ultrasonic diagnostic apparatus according to Embodiment 1.

[FIG 3] A diagram for explaining an operation of the ultrasonic

diagnostic apparatus according to Embodiment 1.

[FIG 4] A block diagram for explaining a configuration of the ultrasonic diagnostic apparatus according to Embodiment 2.

[FIG 5] A block diagram for explaining a configuration of the ultrasonic diagnostic apparatus according to Embodiment 3.

[FIG. 6] A diagram for explaining an operation of the ultrasonic diagnostic apparatus according to Embodiment 3.

[FIG. 7] A block diagram for explaining a configuration of the ultrasonic diagnostic apparatus according to Embodiment 4.

[FIG 8] A diagram for explaining an operation of the ultrasonic diagnostic apparatus according to Embodiment 4.

[FIG. 9] A block diagram for explaining a configuration of the ultrasonic diagnostic apparatus according to Embodiment 5.

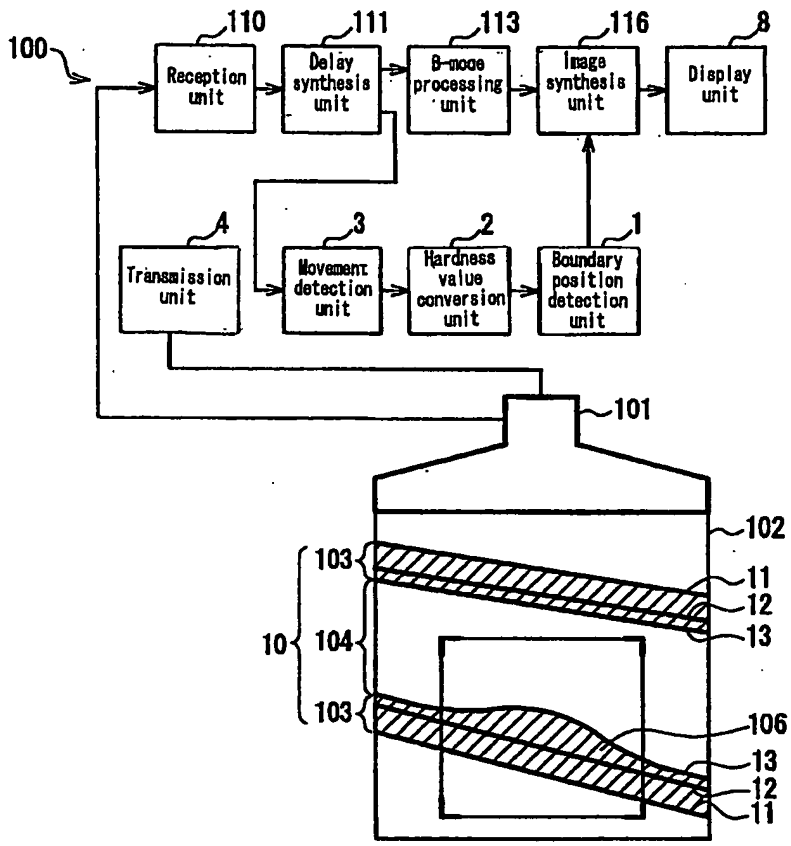
[FIG 10] A diagram for explaining an operation of the ultrasonic diagnostic apparatus according to Embodiment 5.

[Description of the Reference Numerals]

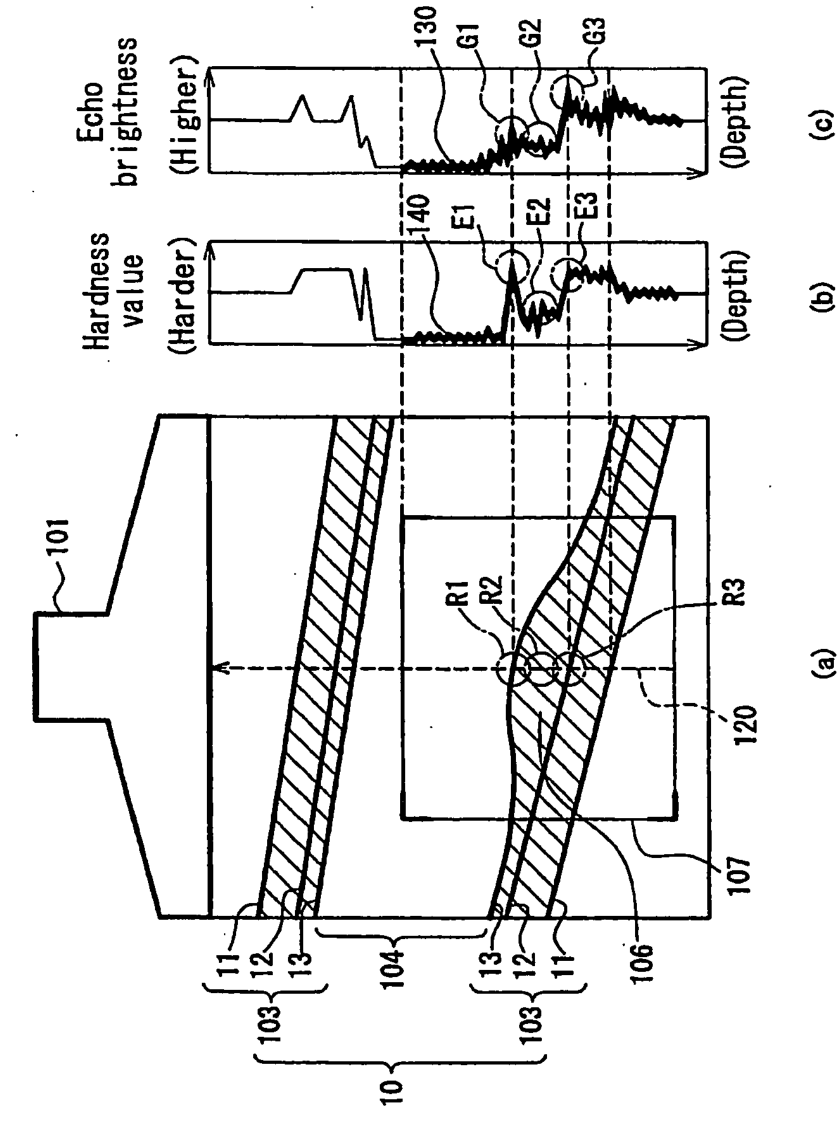
1	boundary position detection unit
2	hardness value conversion unit
3	movement detection unit
4	transmission unit
6	region of interest placement unit
8	display unit
10	blood vessel
11	outer membrane
12	middle membrane
13	inner membrane
24	IMT calculation unit

25 angle correction unit

[Document Name] Drawings
[FIG. 1]

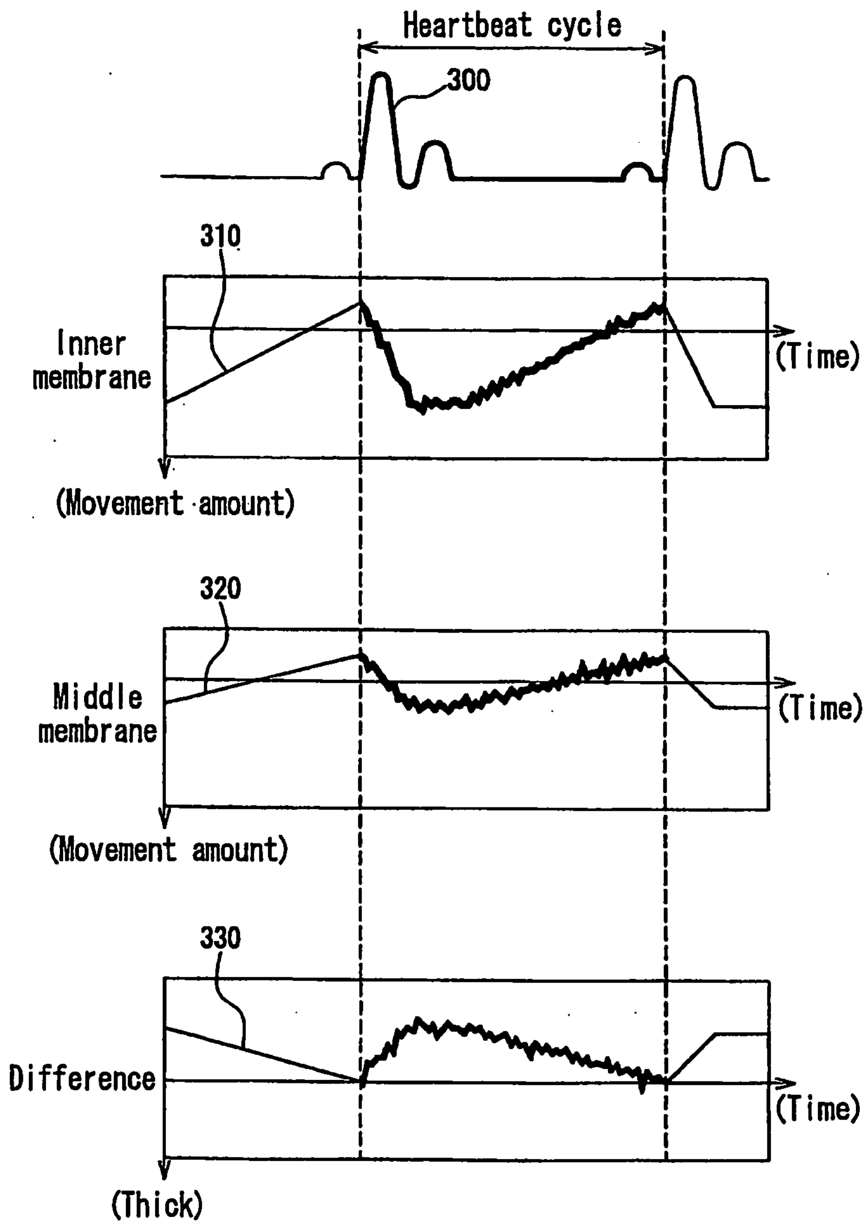


[FIG. 2]

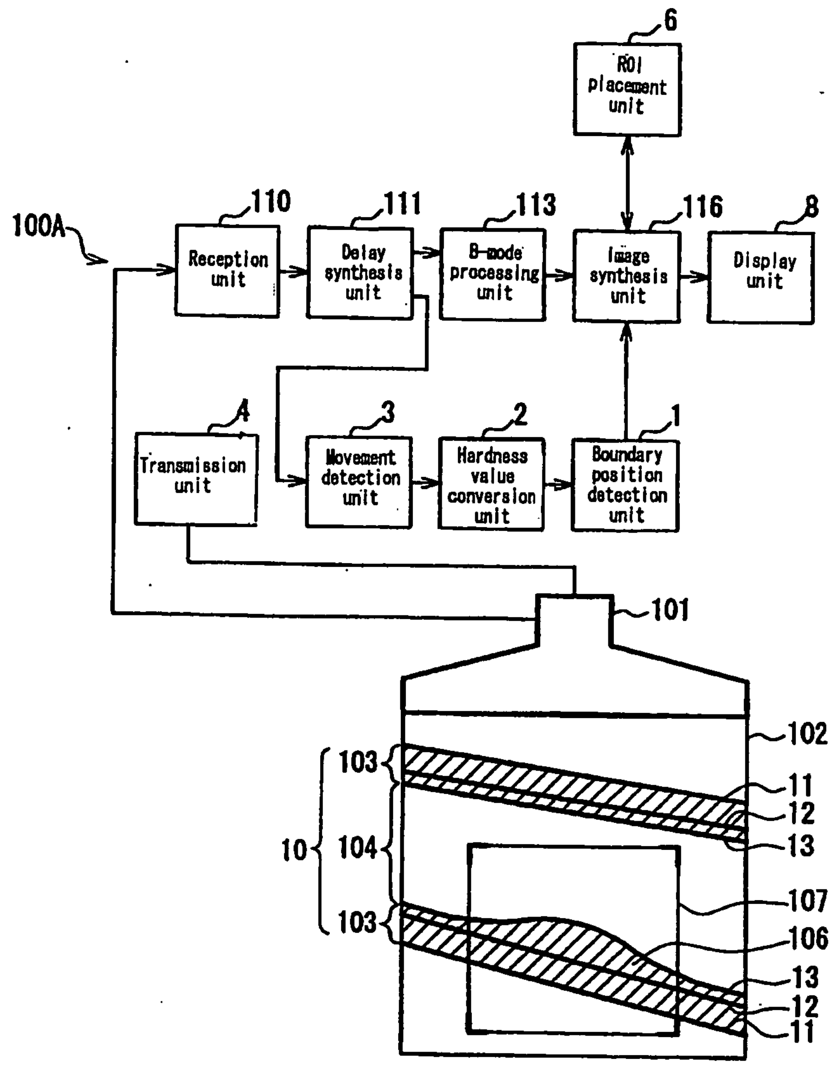


Echo brightness
(Higher)
(Depth)
(c)
130
G1
G2
G3
Hardness value
(Harder)
(Depth)
(b)
140
E1
E2
E3
101
R1
R2
R3
120
107
106
11
12
13
104
103
10
(a)

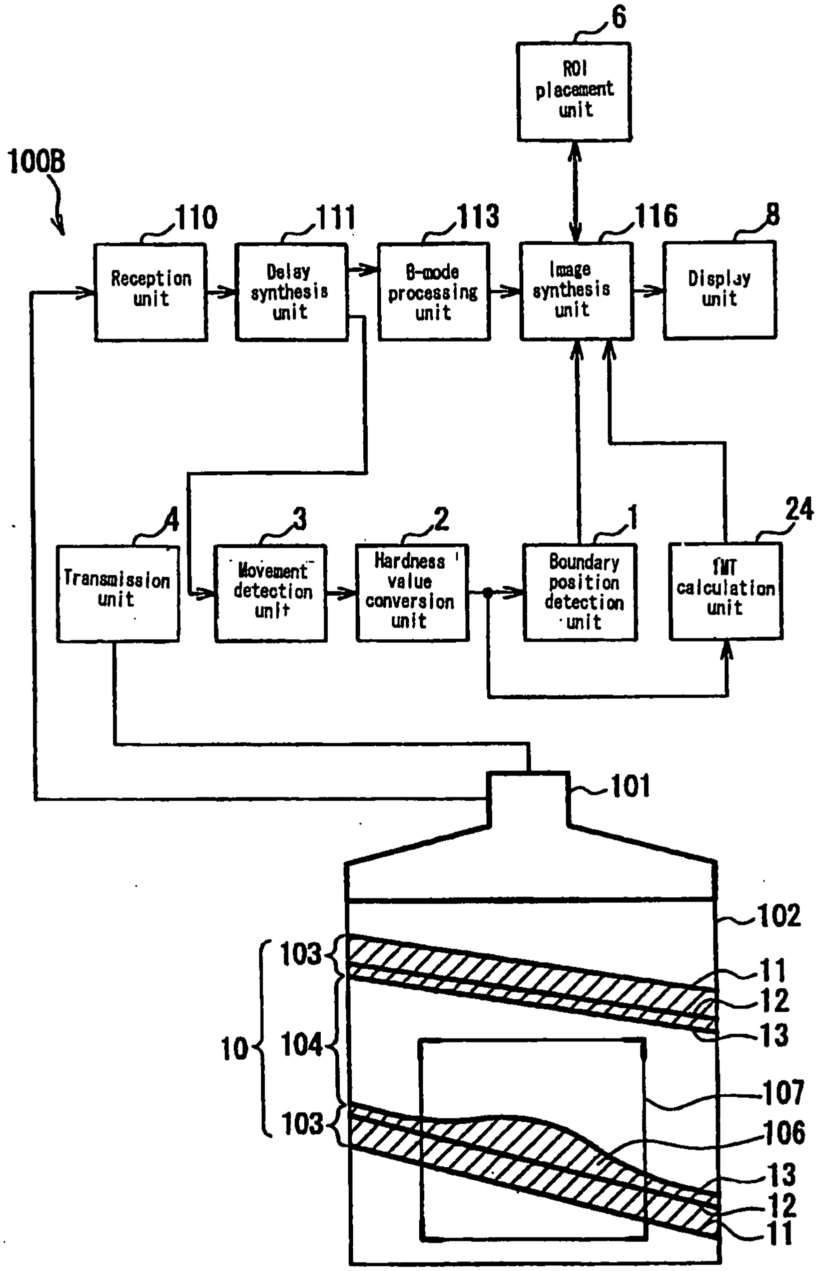
[FIG. 3]


Heartbeat cycle
300
310
Inner membrane
(Time)
(Movement amount)
320
Middle membrane
(Time)
(Movement amount)
330
Difference
(Time)
(Thick)

[FIG. 4]

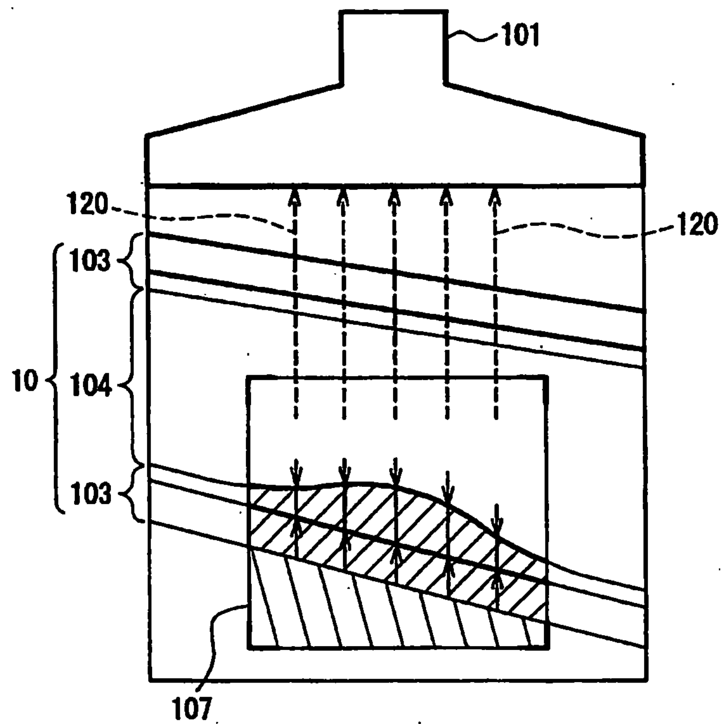

6
ROI placement unit
100A
110
Reception unit
111
Delay synthesis unit
113
B-mode processing unit
116
Image synthesis unit
8
Display unit
4
Transmission unit
3
Movement detection unit
2
Hardness value conversion unit
1
Boundary position detection unit
101
102
103
10
104
103
11
12
13
107
106
13
12
11

[FIG. 5]

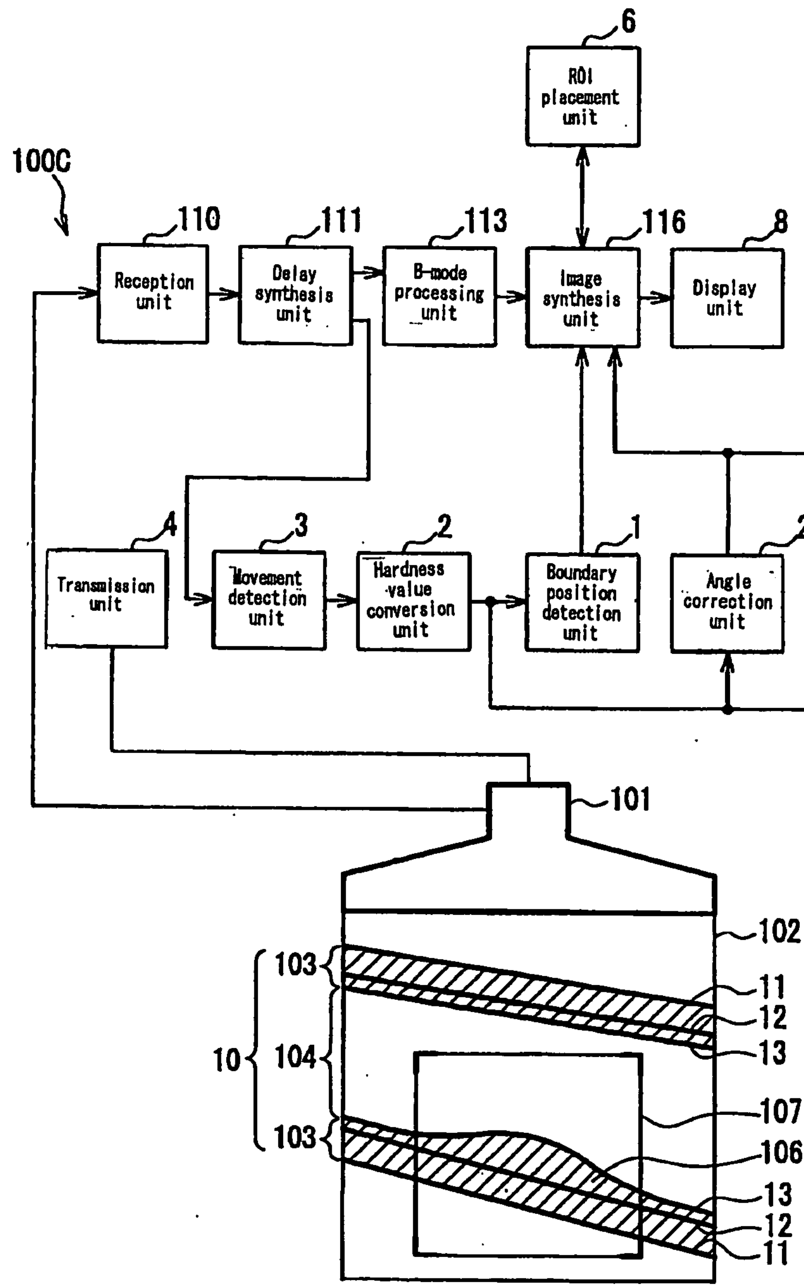


100B
ROI placement unit
6
Reception unit
110
Delay synthesis unit
111
B-mode processing unit
113
Image synthesis unit
116
Display unit
8
Transmission unit
4
Movement detection unit
3
Hardness value conversion unit
2
Boundary position detection unit
1
IMT calculation unit
24
101
102
103
104
10
11
12
13
107
106

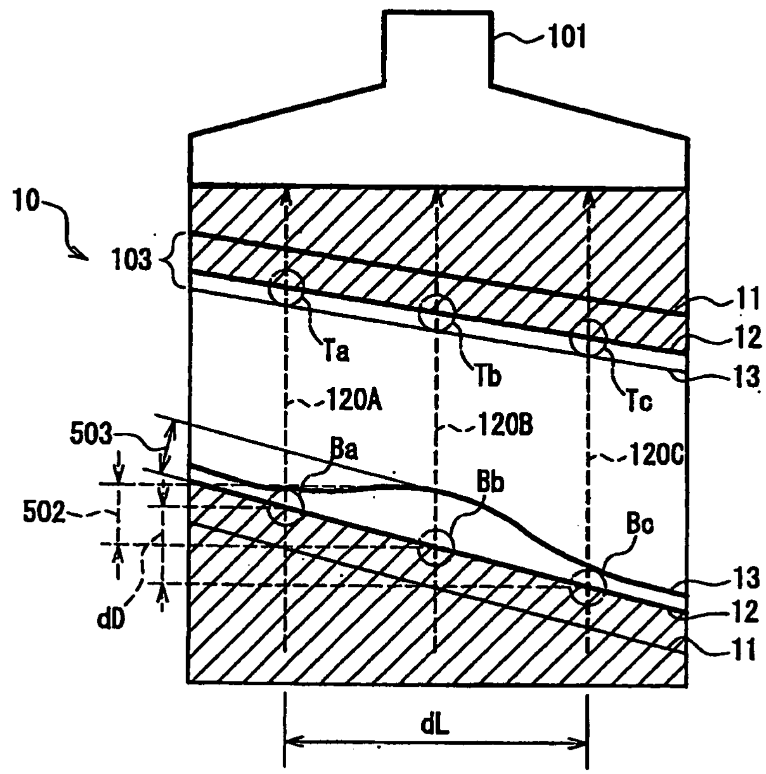
[FIG. 6]



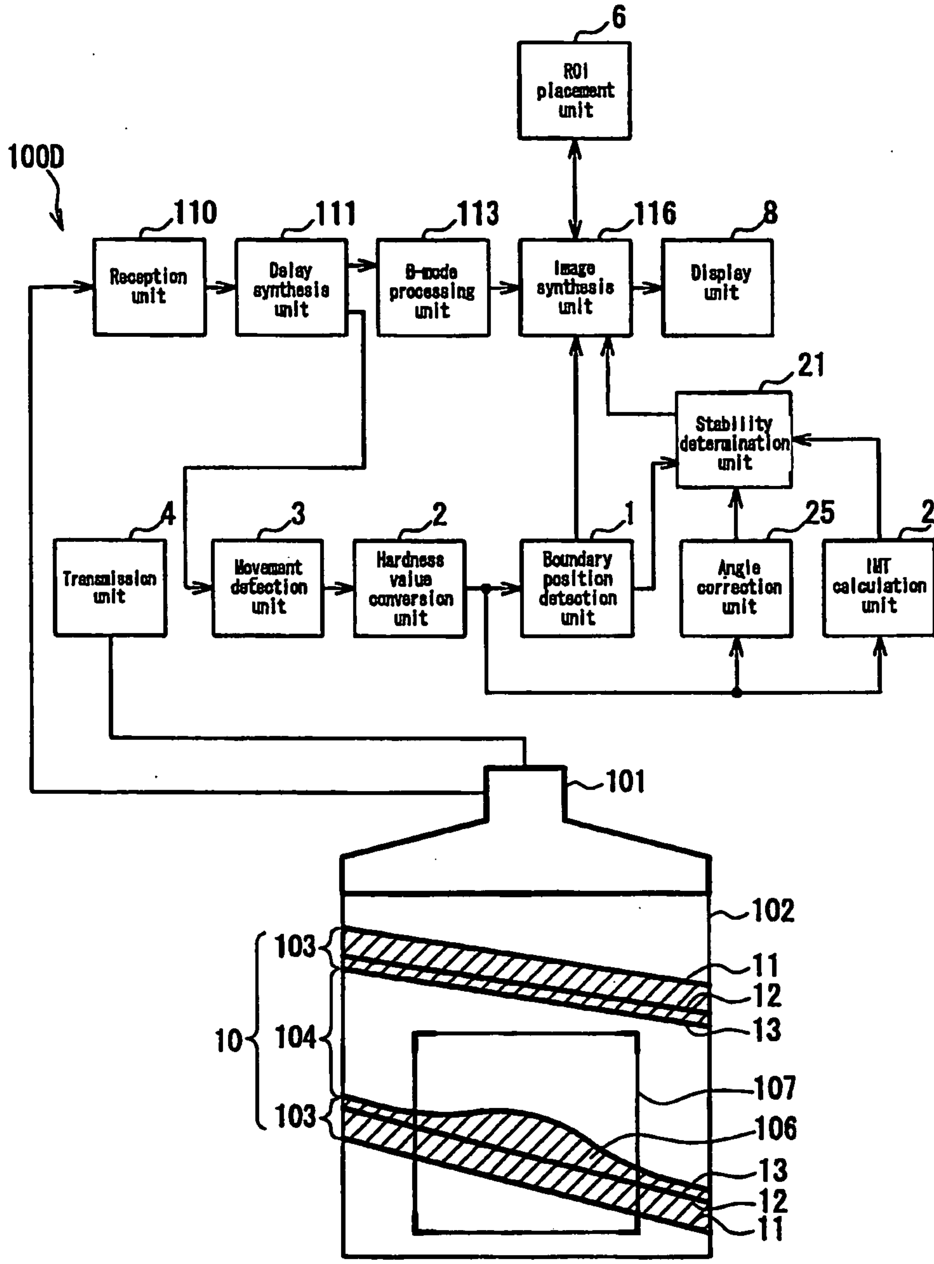
[FIG. 7]


100C
110
Reception unit
111
Delay synthesis unit
113
B-mode processing unit
116
Image synthesis unit
8
Display unit
6
ROI placement unit
4
Transmission unit
3
Movement detection unit
2
Hardness value conversion unit
1
Boundary position detection unit
25
Angle correction unit
24
IMT calculation unit
101
102
103
104
10
103
11
12
13
107
106
13
12
11

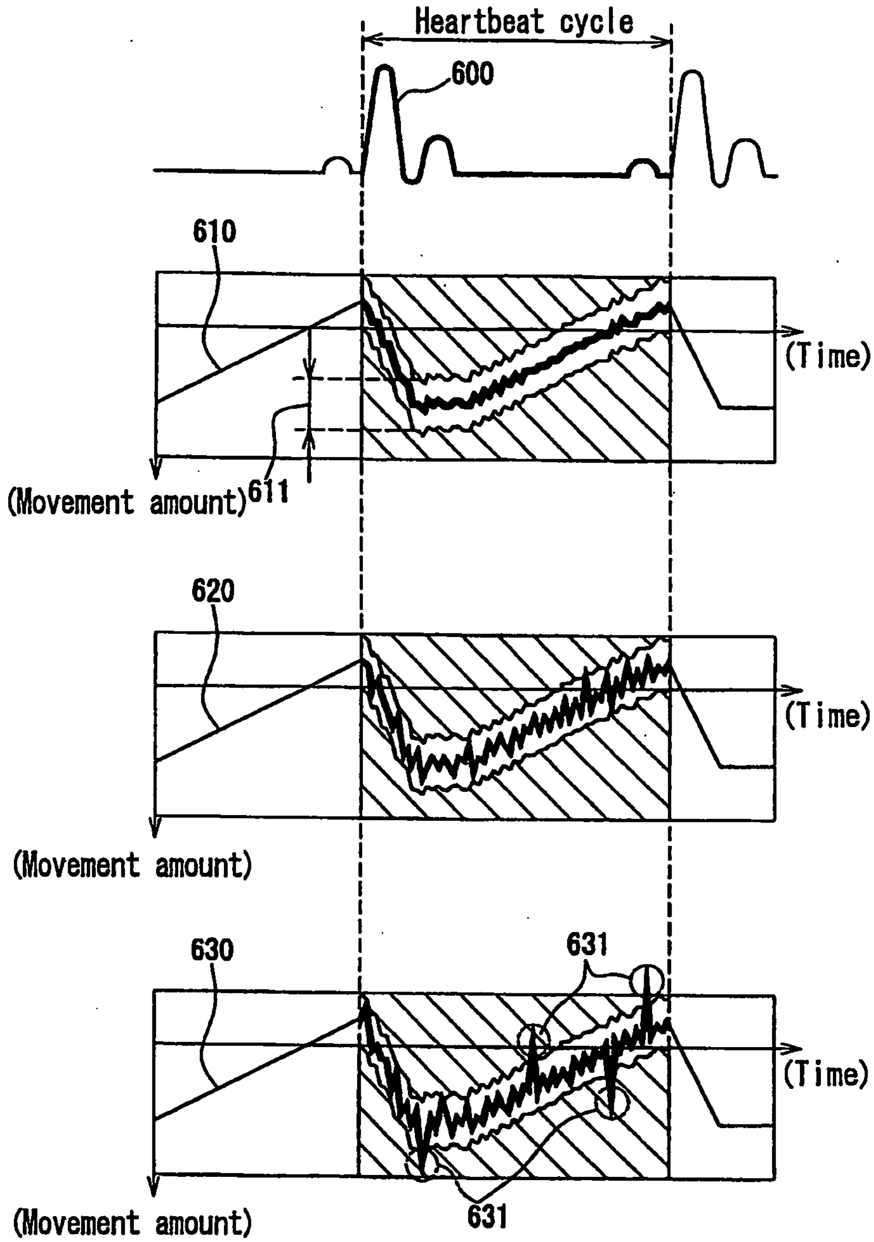
[FIG. 8]


101
10
103
11
12
13
Ta
Tb
Tc
120A
120B
120C
503
Ba
Bb
502
Bc
13
12
11
dD
dL

[FIG. 9]


6
ROI placement unit
100D
110
Reception unit
111
Delay synthesis unit
113
B-mode processing unit
116
Image synthesis unit
8
Display unit
21
Stability determination unit
4
Transmission unit
3
Movement detection unit
2
Hardness value conversion unit
1
Boundary position detection unit
25
Angle correction unit
24
IMT calculation unit
101
102
103
11
12
13
10
104
107
103
106
13
12
11

[FIG. 10]


Heartbeat cycle
600
610
(Time)
(Movement amount)
611
620
(Time)
(Movement amount)
630
631
(Time)
(Movement amount)
631

[Document Name] ABSTRACT

[Abstract]

[Objective] To provide an ultrasonic diagnostic apparatus that is capable of correctly measuring an IMT value using ultrasonic waves.

[Means for Solving the Problem] An ultrasonic diagnostic apparatus 100 includes a transmission unit 110, a reception unit 4, a movement detection unit 3 that analyzes a phase of an ultrasonic signal of a blood vessel 10 in a direction intersecting a center axis so as to calculate a movement amount of a blood vessel wall 103, a hardness value conversion unit 2 that converts a phase change of an ultrasonic echo signal to a hardness value of tissues along a depth direction from a surface of a skin, and a boundary position detection unit 1 that detects a boundary position between an inner membrane 13 of a blood vessel 10 and a blood flow region 104 where blood flows through the blood vessel based on the hardness value of tissues along the depth direction, and a position of a middle membrane 12.

[Selected Figure] FIG. 1